2) The software control method of claim 1 wherein the ~~free neighborhood entity is~~plurality of entities comprises an edge.

3) The software control method of claim 1 wherein the ~~free neighborhood entity is~~plurality of entities comprises a triangle.

4) The software control method of claim 1 wherein ~~a free neighborhood~~a first one of entities is a vertex formed at an intersection of a first and a second edge of the modeled object and a corresponding first one of the free neighborhoods is ~~represented~~ defined by an angular ~~portion for different types of entities comprising~~extension of the first and second edges ~~the boundary of the polygon~~.

5) The software control method of claim ~~4~~ 1 wherein a ~~free neighborhood~~first one of the free neighborhoods comprises a material zone represented by a half sphere containing material of the modeled object and delimited by a plane of a triangle.

6) The software control method of claim ~~4~~ 1 wherein ~~the free neighbor hood~~ a first one of the free neighborhoods comprises a tangent zone represented by two portions of a sphere, wherein the two portions of the sphere are delimited by planes of adjacent triangles.

9) The software control method of claim 1 wherein the motion between two consecutive matrices is ~~assumed to be~~ modeled as linear motion.

10) The software control method of claim 1 wherein each free neighborhood comprises an area in which motion of the corresponding entity comprises motion on the boundary of the modeled swept volume~~an entity comprising an object and moving inside the material path of the object are filtered~~.

11) A computer system for controlling generation of a swept volume model, the system comprising:

a processor operatively interconnected to a memory;

a user input device;

a display; and

a graphical user interface responsive to activation with the user input device by causing ~~the~~ a program stored in the memory to be executed by the processor, ~~wherein~~ said program configuring the processor to perform computations whereby:

a polyhedral representation comprising a plurality of entities of a computer modeled object is generated,~~;~~

motion of the object is represented with a set of position matrices,~~;~~

for each of a series of sequential positions of the object represented by the matrices,

a subset of the~~free neighborhood~~ entities comprising entities remaining within their corresponding free neighborhood during motion of the object from a current to a next position is determined ~~for each matrix~~,~~;~~ and

traces are generated by the motion of the ~~free neighborhood~~subset of entities ~~entities~~during motion between a current and a next position.~~;~~ and

a representation of the swept volume is constructed from the traces.

12) The computer system of claim 11 wherein the position matrices representing motion ~~of the free neighborhood entities are created referencing a database comprising~~ comprise data collected during physical experiments.

13) The computer system of claim 11 wherein the position matrices representing motion of the free neighborhood entities are calculated in response to selection of a motion type from a user interactive menu.

14) The computer system of claim 11 wherein a ~~free neighborhood entity~~ first one of the entities comprising an edge has a corresponding free neighborhood comprising a tangent zone, and the first entity ~~comprising an edge~~ is determined to be a member of the subset based on ~~by~~ testing ~~for~~ to detect movement of the edge through the ~~a~~ tangent zone.

15) The computer system of claim 11 wherein a ~~free neighborhood entity~~ first one of the entities comprising a triangle has a corresponding free neighborhood comprising a material zone, and the first entity ~~comprising a triangle~~ is determined ~~by~~ to be a member of the subset based on testing for movement of the triangle through the ~~a~~ material zone.

17) A computer program residing on a computer-readable medium, the program comprising instructions for causing the computer to:

generate a polyhedral representation of a computer modeled object, the representation comprising a plurality of entities;

represent motion of the object with a set of position matrices representing sequential positions of motion of the object; and

for each of a series of sequential positions of the object,

> determining a plurality of free neighborhoods, each free neighborhood corresponding to one of the plurality of entities
>
> determine a subset of the entities comprising entities having a trajectory through their corresponding free neighborhood during motion of the object from a current position to a next position represented by the matrices, ~~free neighborhood entities comprising the object for each matrix;~~
>
> generate a trace of ~~traces by~~ the motion of the free neighborhood entities between the current and the next position; and

construct a representation of the swept volume from the generated traces.

18) The computer program residing on a computer-readable medium of claim 19 wherein each free neighborhood comprises an area in which motion of the corresponding entity comprises motion on the boundary of the modeled swept volume~~an entity comprising an object and moving inside the material path of the object are filtered~~.

Please add the following new claims

21) A software-implemented method of modeling a swept volume of a computer simulated object, the method comprising:

storing data representing a plurality of sequential positions of the object;

for each of the plurality of sequential positions, computing the swept volume of the object as the object moves between a current one of the positions and a next one of the positions, the swept volume being computed by:

determining a first plurality of entities belonging to a boundary of the object and to a boundary of the modeled swept volume as the object moves between the current and the next position, wherein determining the first plurality comprises:

for each of a second plurality of entities comprising entities on the boundary of the object that are also on the boundary of the swept volume and entities on the boundary of the object that are not on the boundary of the swept volume,

determining a plurality of free neighborhoods each free neighborhood being associated with a corresponding one of the second plurality of entities and each free neighborhood comprising an area wherein motion of the corresponding one of the entities comprises motion on the boundary of the swept volume,

computing trajectory of each of the entities during motion between the current and next position of the object to determine whether each entity moves within its corresponding free neighborhood, and

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designating each entity moving within in its corresponding free neighborhood as a member of the first subset; and

forming a subsection of the boundary of the swept volume by tracing the first subset of entities in motion between the current position and the next position.

22. The method of claim 21 wherein the plurality of entities comprise modeled object features selected from the group consisting of object edges and object vertices.

23. The method of claim 22 wherein each free neighborhood comprises a free neighborhood type selected from the group consisting of a material zone and a tangent zone.

24. The method of claim 23 wherein material zone free neighborhoods are associated with object edge entities and wherein tangent zone free neighborhoods are associated with object vertex entities.

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**<u>In the Abstract</u>**

A replacement Abstract sheet has been provided.

## <u>REMARKS</u>

Claims 1-20 were rejected in an Office Action mailed October 22, 2000.

Claims 1-6, 9-15, 17-18 have been amended. Claims 16, 19-20 have been deleted. Claims 21-24 have been added.

No new matter has been added.

Applicant's remarks, below, may be preceded by quotations of related comments of the Examiner, presented in small bold-face type.

Abstract

> 3. The abstract is objected to because of the period (.) in line 8 after the word polygon . . . See MPEP § 608.01(b).

A replacement abstract sheet has been provided in which the referenced period (.) in line 8 has been changed to a comma (,).

Rejections under 37 C.F.R. § 1.75 (d)(1):

> 5. Claims 10 and 11 are objected to because of the following informalities . . . Claim 10 . . . is grammatically incorrect. . . . Claim 11 . . . is grammatically incorrect.

Claims 10 and 11 have been amended to correct grammatical errors.

Rejections under 35 USC § 101.

> 6. . . . Claims 1-20 are rejected under 35 U.S.C. 101 because the claimed inventions are directed to non-statutory subject matter. Claim 1 recites a mathematical algorithm . . . A mathematical algorithm is not statutory subject matter . . . Claim 11 involves a mathematical algorithm . . . A mathematical algorithm is not statutory subject matter.

It is well established that reciting a mathematical algorithm does not render a claim non-statutory as long as the claim produces a "useful, concrete and tangible result. " See MPEP § 2106 citing *State Street Bank & Trust Co. v. Signature Financial Group, Inc.*, 47 USPQ2d at 1601-02 (Fed. Cir. 1998). As noted by MPEP § 2106, in *State Street*, the Federal Circuit held that a process by which data representing monetary amounts was transformed to a different value (a final share price) produced a "useful, concrete and tangible result" in the form of a number. See also *AT&T Corp. v. Excel Communications, Inc.*, 50 USPQ2d 1447, 1452 (Fed. Cir. 1999) (claims drawn to a long-distance telephone billing process containing mathematical algorithms were held to be directed to patentable subject matter because ' the claimed process applies the Boolean principle to produce a useful, concrete, tangible result without pre-empting other uses of the mathematical principle."

Further, quoting MPEP § 2106 "Office personnel [the Examiner] have the burden to establish a *prima facie* case that the claimed invention as a whole is directed to solely an abstract idea or to manipulation of abstract ideas or does not produce a useful result. Only when the claim is devoid of any limitation to a practical application in the technological arts should it be rejected under 35 U.S.C. 101 . . . Further, when such a rejection is made, Office personnel must expressly state how the language of the claim has been interpreted to support the rejection."

Each of the pending claims is limited to a useful and practical application - i.e., computing and manipulating swept volume models. The pending claims are not directed merely to abstract ideas, nor are they devoid of any limitation to a practical application in the technological arts. For at least the foregoing, and for other the reasons set forth in MPEP § 2106, rejection of claims by the Examiner under 35 U.S.C. § 101 is improper. Consequently, the undersigned respectfully request that the Examiner withdraw all rejections under 35 U.S.C. § 101.

<u>Rejections under 35 USC § 102(e)).</u>

> **8. claim 1 is rejected under 35 U.S.C. 102 (e) as being clearly anticipated by Xavier (XA).**

Although both Xavier and the present application relate to the field of computer aided design and modeling, and both Xavier and the present application employ swept volume calculations, the swept volume calculations claimed in the present invention are not disclosed or suggested by Xavier.

Claim 1 may be better understood with reference to added claim 21. Although the scope of claim 1 and of claim 21 do differ (for example, claim 1 explicitly recites the use of "position matrices" and of a "polyhedral representation", while claim 21 does not), the undersigned believes that a review of claim 21 may be helpful in understanding claim 1.

Claim 21 recites a software-implemented method of modeling a swept volume of a computer simulated object. The method includes storing data representing a plurality of sequential positions of the object and, for each of the plurality of sequential positions,

computing the swept volume of the object as the object moves between a current one of the positions and a next one of the positions. As recited by claim 21, the swept volume is computed by determining a first plurality of entities belong to a boundary of the object and to a boundary of the modeled swept volume as the object moves between the current and the next position. This first plurality is a subset of a second plurality that also further includes entities on the boundary of the object that are not on the boundary of the swept volume. That is, the recited method includes selecting from a larger group of entities (the larger group including entities that will be considered as being on the boundary of the modeled swept volume and other entities that will not be considered on the to this boundary) a first subset of entities that will be used to form a boundary of the swept volume.

Claim 21 further recites processes whereby the first plurality can be determined. These processes are based on the computation of "<u>free neighborhoods</u>" of each entity. The "free neighborhoods" may then be used to determine the entities on the boundary of the swept volume. More particularly, claim 21 recites determining a plurality of free neighborhoods each comprising an area wherein motion of the corresponding one of the entities comprises motion on the boundary of the swept volume. Thus, the method includes <u>determining an area in which an entity can move while remaining on the swept volume boundary (the application defines this are as a "free neighborhood")</u>. To determine whether an entity remains in its free neighborhood or not, the method includes computing a trajectory of each of the entities during motion between the current and next position of the object. Each entity remaining in its corresponding free neighborhood is designated as a member of the first subset. The method concludes with forming a subsection of the boundary of the swept volume by tracing the first subset of entities in motion between the current position and the next position.

Referring now to claim 1, claim 1 has been amended to clarify the claimed invention. Claim 1 now recites a method of modeling a swept volume of a computer simulated polyhedral representation of an object. More specifically, claim 1 recites a software control method of modeling a swept volume for a computer simulated object. The method includes generating a polyhedral representation of a computer modeled object, the representation comprising a plurality of entities, representing motion of the object as a series

of sequential positions of the object, determining free neighborhoods associated with the entities. The method also determines a subset of the entities having a trajectory through their corresponding free neighborhood during motion of the object from a current position to a next position, and generating traces of the motion of the free neighborhood entities between the current and the next position, and constructing a representation of the swept volume from the traces.

Referring now to the Examiner's comment in paragraph 10.2 of the Office Action, which states:

> [claim 1] specifies, "Determining a subset of free neighborhood entities comprising the object for each matrix". XA specifies, Col 2, Para 2, "Hierarchical structures use various primitives to bound an object or its surface."

The Examiner, in his comments, suggest that the use of "free neighborhoods" as recited by claims 1 (as well as in other claims including, e.g., claim 21) is disclosed by Xavier. This is not correct. The concept of "free neighborhoods" as presented in the originally-filed claims, and as now further clarified in the amended claims, is not disclosed or suggested in Xavier.

Referring now to the Examiner's cited disclosure, the disclosure at Xavier col. 2, para 2 is not the use of "entities" and "free neighborhoods" as disclosed and claimed in the present application. Xavier's reference to "Hierarchical structures" and "primitives" (at col. 2, Para 2 of Xavier, as cited by the Examiner) refers to collision detection mechanisms in which certain primitive objects are used to bound a surface for purposes of collision detection. These "bound surfaces" are different from the "free neighborhoods" described in the present application and, as disclosed and claimed in the present application, the function of a "free neighborhood" is quite different from that of Xavier's bound surfaces. What a "free neighborhood" is used for is to determine modeled object entities that are on a boundary of a swept volume as a modeled object moves between positions. That is, a "free neighborhood" is used to calculate entities that contribute to a visual representation of a swept volume. The "free neighborhoods" and traced entities recited in claim 1 do not, of themselves, determine collision between objects, but rather are part of a method to

visualizing a swept volume. While the resulting model of the swept volume can be used to determine collisions between objects (swept volume visualizations and models are often useful for such a purpose), this benefit is not achieved directly from the use of free neighborhoods" and entities as recited in the present claims, but rather, would be achieved from a subsequent interpretive process (e.g., by an individual looking at the resultant visualization).

For at least the reason that Xavier does not teach or suggest a method of forming a swept model that includes, for each of a series of sequential positions of an object, determining free neighborhoods associated with entities of that object, determines a subset of the entities having a trajectory through their corresponding free neighborhood during motion of the object from a current position to a next position as represented by position matrices, and generating traces of the motion of the free neighborhood entities between the current and the next position, claim 1 is patentable over Xavier.

Claims 2-10 depend, directly or indirectly, on claim 1 and are patentable for at least the reasons set forth for claim 1.

> 15. Claim 11 is rejected under 35 U.S.C. 102(e) as being clearly anticipated by XA.
>
> 21. Claim 17 is rejected under 35 U.S.C. 102(e) as being clearly anticipated by XA.

As for claim 1, claims 11 and 17 and their dependent claims 12-15, and 18 recite the use of "free neighborhoods" and the use of those "free neighborhoods" to determine object entities from which a swept volume is traced. As with claim 1, the calculating swept volumes using "entities" and "free neighborhoods" is a substantial difference from the computation of collusions as taught and disclosed by Xavier. For substantially the same reasons set forth for claim 1, above, claims 11 and 17 and their dependent claims 12-15, and 18 are patentable over Xavier.

## CONCLUSION

Claims 1-6, 9-15, 17-18 have been amended. Claims 16, 19-20 have been deleted. Claims 21-24 have been added.

Claims 1-15, 17-18, 21-24 are now pending and believed to be in condition for allowance. Applicant respectfully requests that all pending claims be allowed.

Please apply any credits or excess charges to our deposit account number 50-0521.

Respectfully submitted,

Date: Feb 6, 2002

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